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Tracking of motor vehicles from aerial video imagery using the OT-MACH correlation filter

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Introduction

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- Accurately tracking moving targets in a complex scene involving moving cameras, occlusions and targets embedded in noise is a very active research area in computer vision.
- An optimal trade-off maximum correlation height (OT-MACH) filter has been designed and implemented as a robust tracker.
- The algorithm allows selection of different objects as a target, based on the operator’s requirements.
- The tracker has been tested on both colour visible band as well as infra-red band video sequences acquired from the air by the Sussex County police helicopter.

OT-MACH Filter

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Frequency domain Optimal Trade-off Maximum Average Correlation Height (OT-MACH) filter function (Mahalanobis *et al)*

OT-MACH tunable nature gives :

- ability to produce easily detected correlation peaks
- tolerance to untrained target object distortions
- ability to suppress noise/clutter

OT-MACH Filter

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Frequency domain Optimal Trade-off Maximum Average Correlation Height (OT-MACH) filter function:

$$h = \frac{m_x^*}{\alpha C + \beta D_x + \gamma S_x}$$

- α, β and γ are the OT-MACH (non-negative) parameters
- m^* is the average of the training images
- C is the diagonal matrix of the power spectral density of additive input noise, where we $C = \sigma_{input} / \mu_{input}, \alpha = 1$
- Dx is the diagonal matrix of the average power spectral density of the training images
- Sx is the similarity matrix of the training images

Target Initialisation

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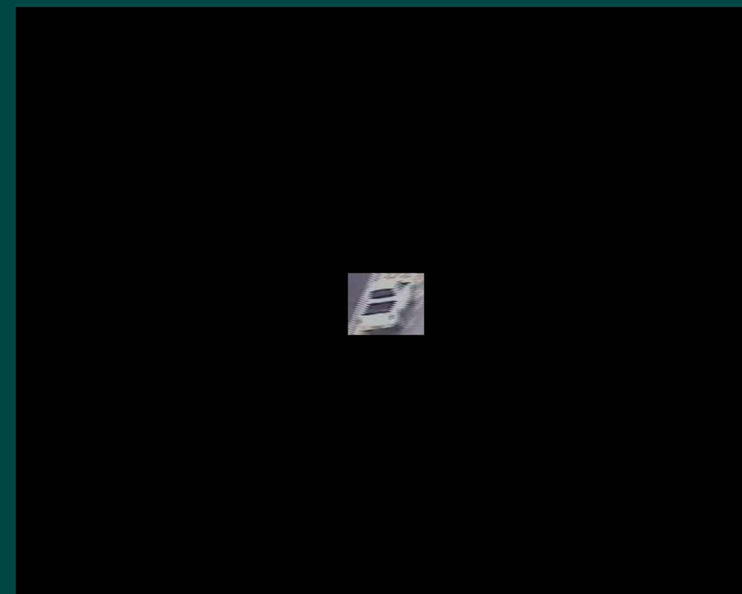
Initialisation circle over target vehicle



Target reference image used to train filter

Active contour based target extraction

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An energy functional is computed and iterated for each co-ordinate point around the object:

$$E^*_{snake}(s) = E_{\mathrm{int}}(v_s) + E_{image}(v_s)$$

The continuously up-dated snake energy :

$$E^*_{snake} = \alpha(s).\left|\frac{dv_s}{ds}\right|^2 + \beta(s).\left|\frac{d^2 v_s}{ds^2}\right|^2 + \gamma(s)E_{edge}$$

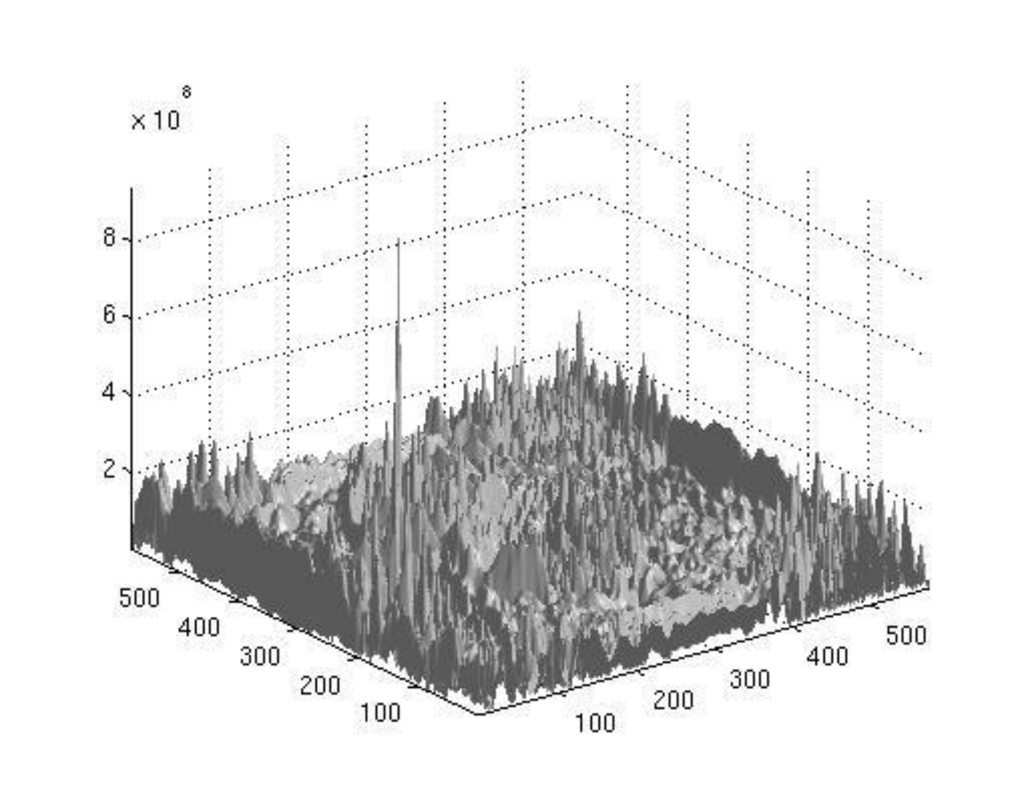
Reference image with mapped contour

Target reference image used to train filter

Rotationally multiplexed reference image

Target reference image used to train filter

Correlation Plane Response



Correlation Plane with peak location (x,y)= (195, 342)

Tracker Results on test video

Kalman filter (Red) and OT-MACH filter tracker (Yellow)

Tracker Results on test video

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Particle filter (blue, green and red) and
OT-MACH filter tracker (Yellow)

False object rejection

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Sussex Police video (1) Frame 5 with false objects

Tracker results

Sussex Police video (1) Frame 15 with multiple false objects

Tracker results

Sussex Police video (1) Frame 240, scale changed

IR tracker results

Sussex Police infra-red video frame 104, scale changed with Gaussian noise

IR tracker results

Sussex Police infra-red video frame 265, scale changed

IR tracker results

Sussex Police infra-red video frame 435, scale and orientation changed

Colour camera, variable lighting

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Sussex Police video (3) frame 35

Colour camera, variable lighting

Sussex Police video (3) frame 548, scale and orientation changed

Conclusions

- The OT-MACH filter has been optimised and implemented as a robust vehicle tracker

- The filter is rotation multiplexed and applied at a frame rate initialised by the user on the video sequences, with a filter up-date being implemented every m frames

- Compared to rectangular and circular extraction methods the active contour snake is found to allow the maintenance of a strong and accurate correlation peak at the target location

Conclusions

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- The OT-MACH filter is frequently updated by retraining with rotationally multiplexed reference images extracted and processed during an interval period chosen by the user.
- From the tests performed to date, the OT-MACH tracker shows considerable promise and has the capability to perform accurately in cluttered and noisy sequences
- The filter is found to be accurate in recognising and tracking the target, out-performing an extended Kalman filter and colour based Particle filter approach in noisy and dynamic sequences

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